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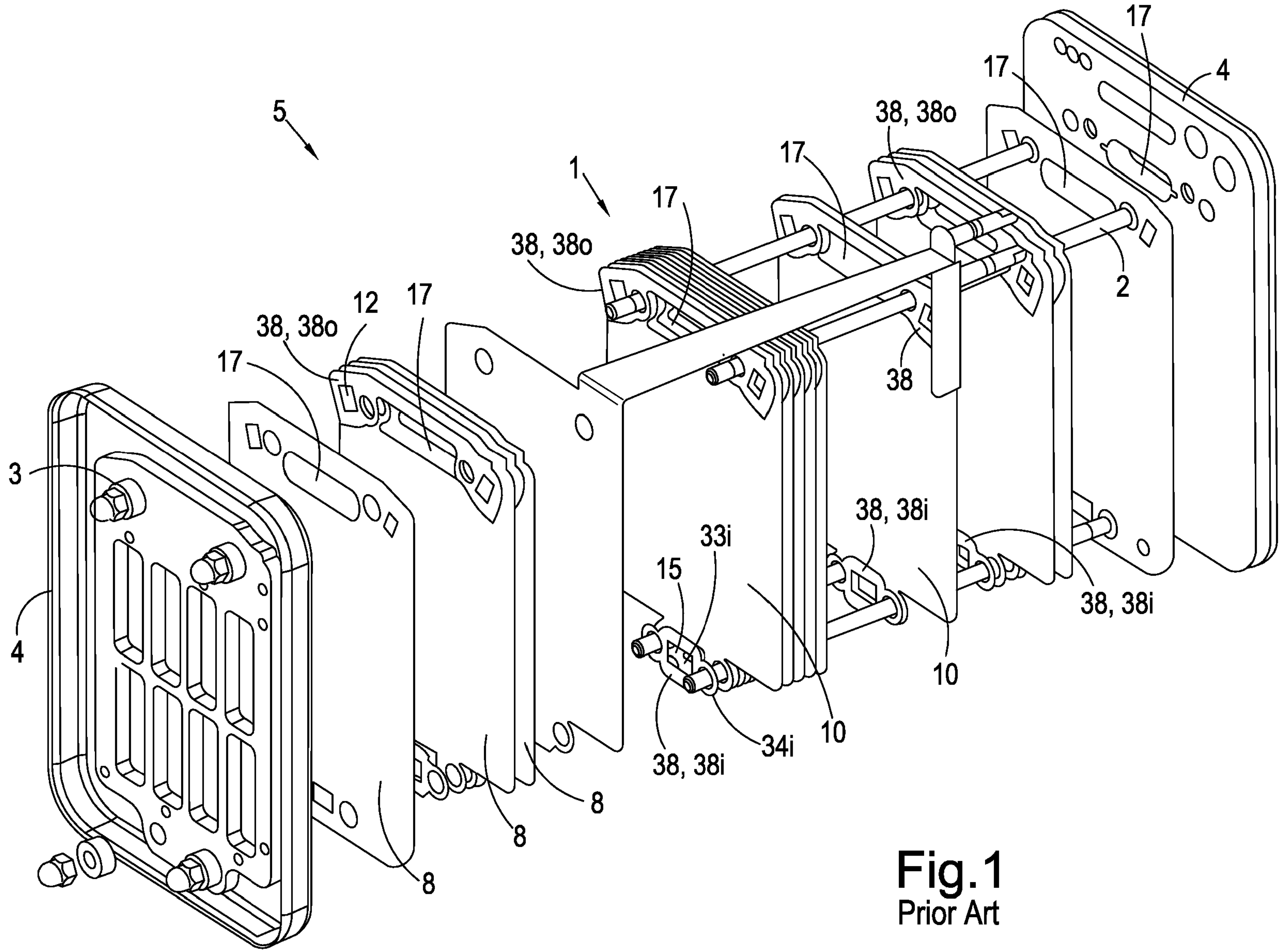

Fig.1
Prior Art

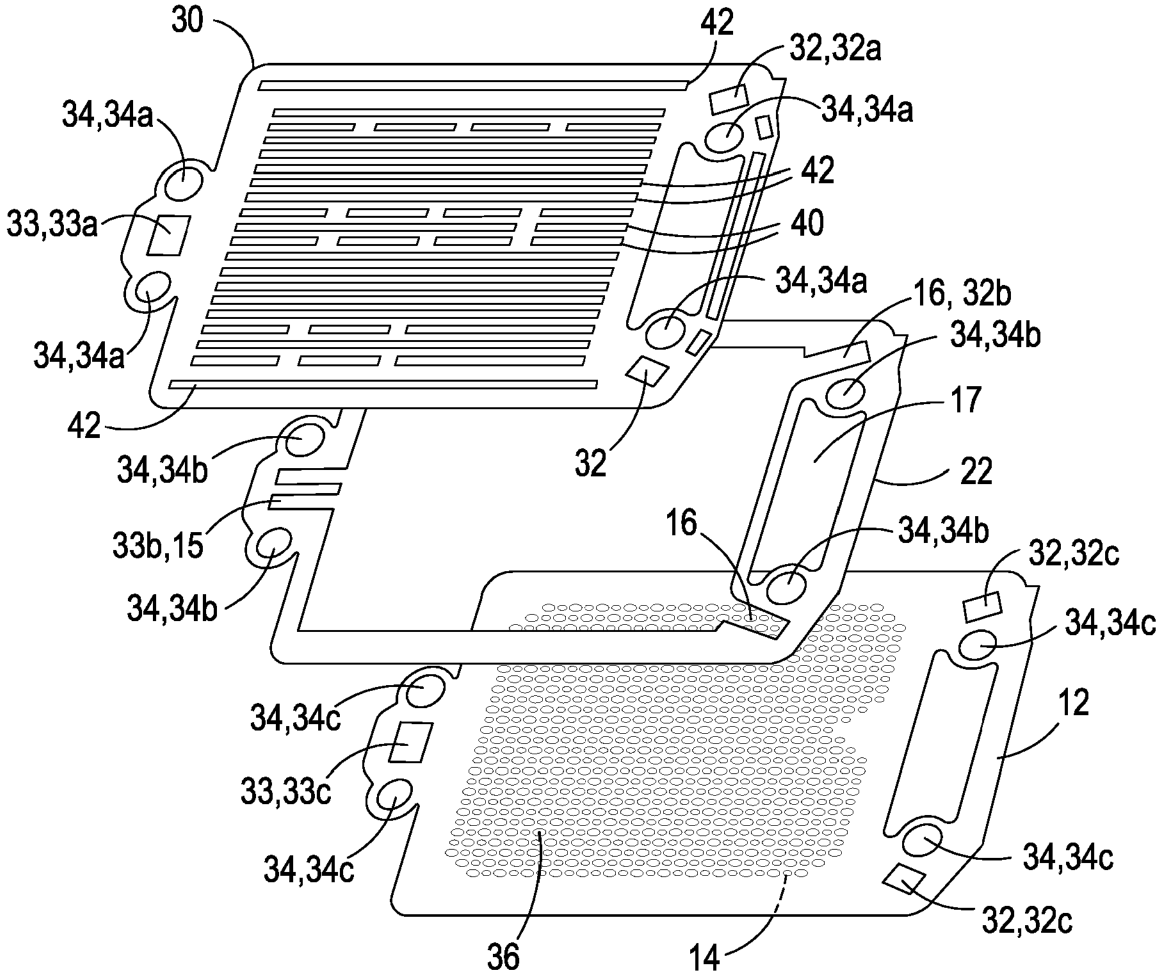

Fig.2
Prior Art

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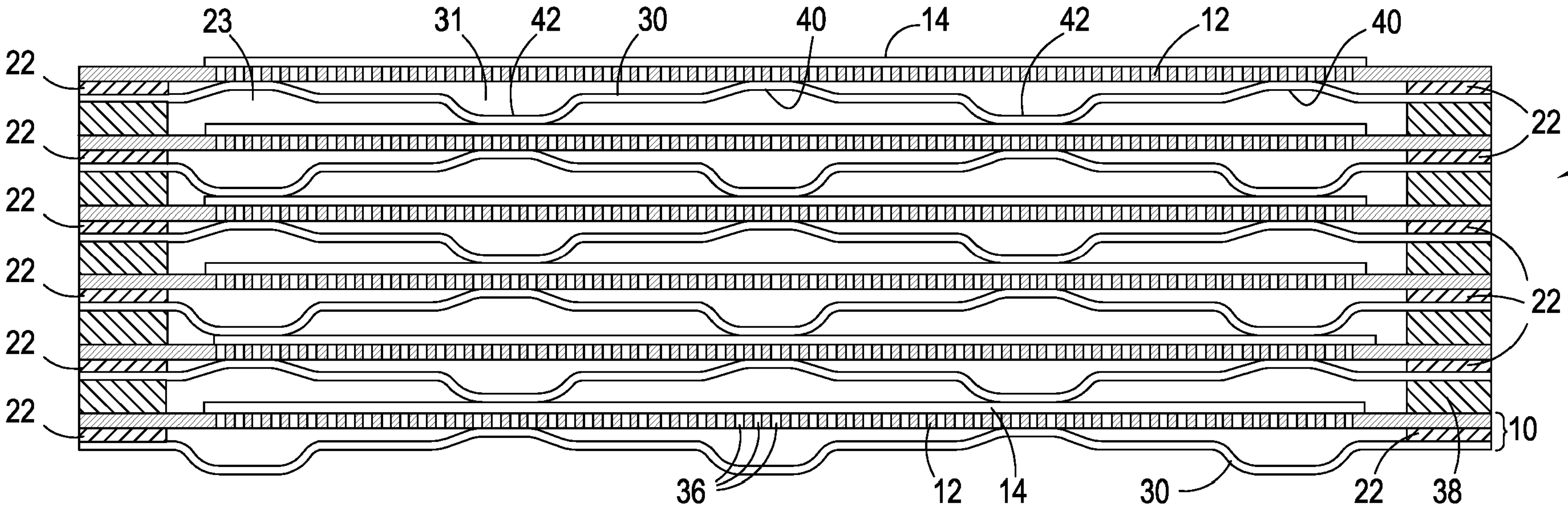

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Fig.3

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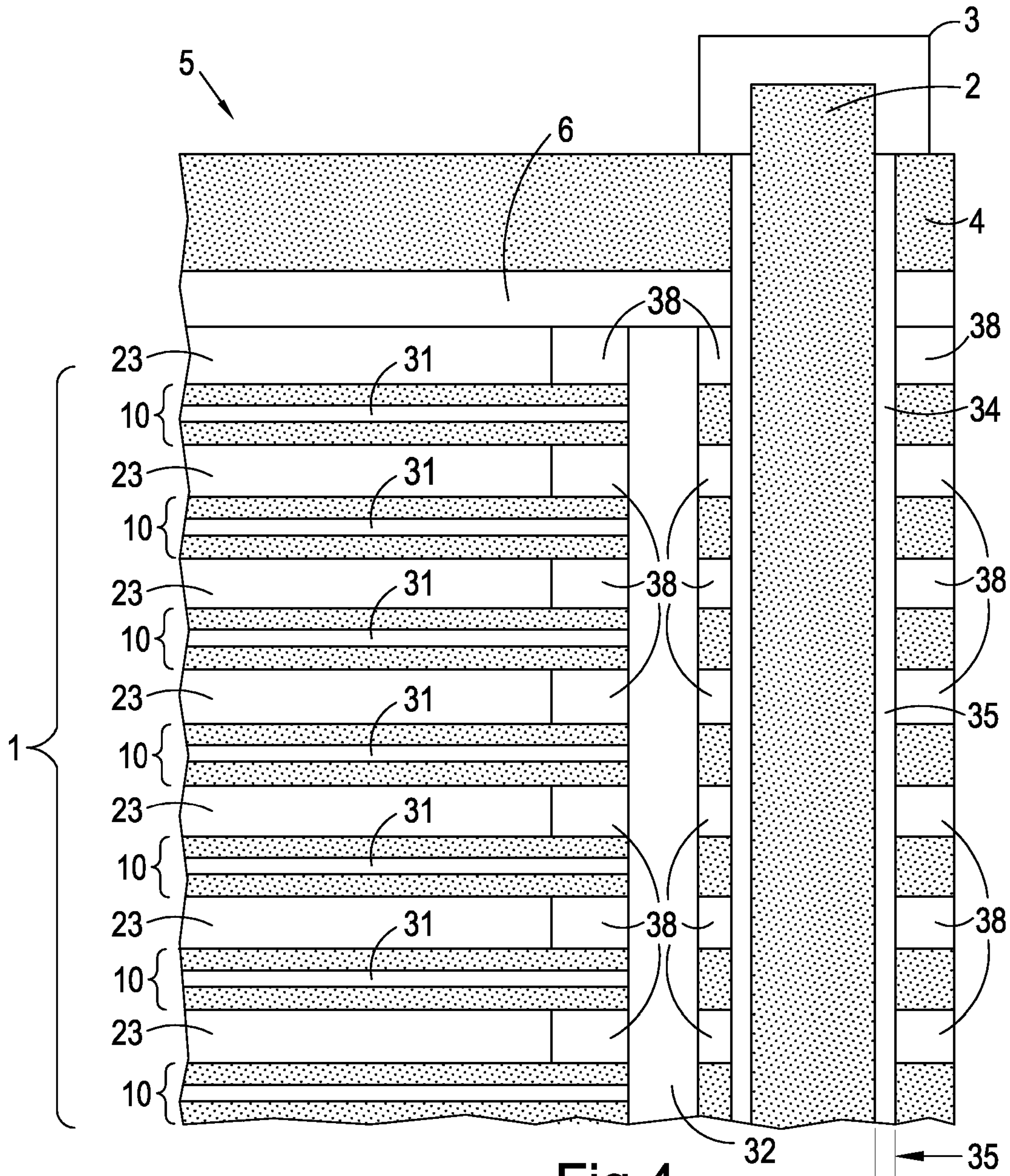

Fig.4

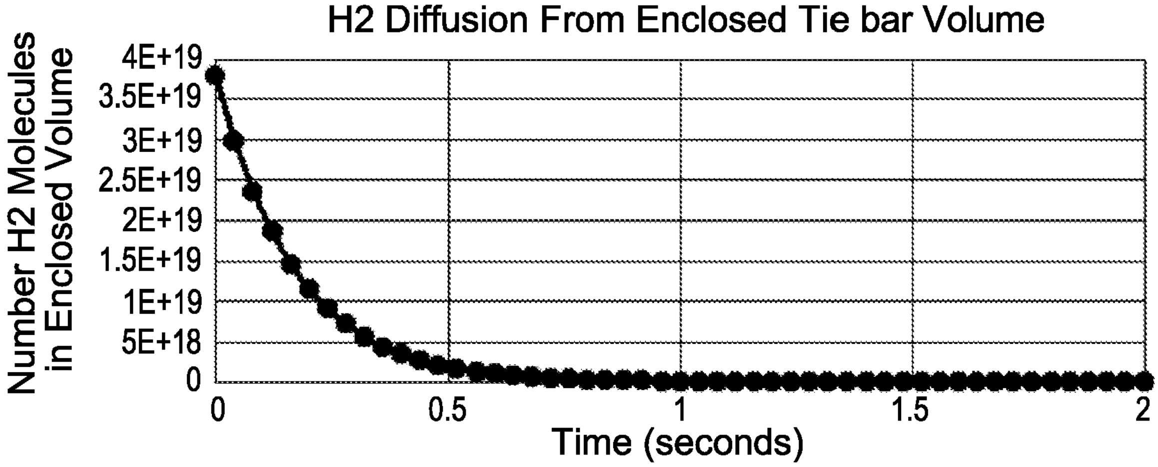

Fig.5

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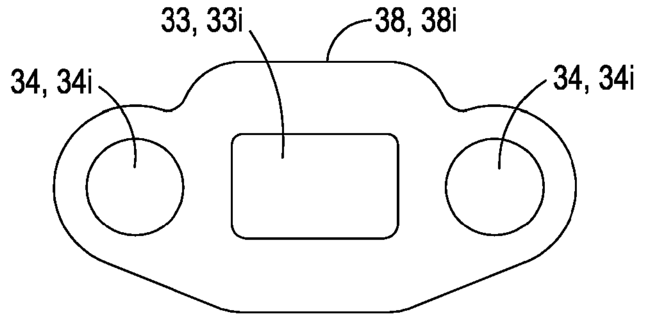

Fig.6 PRIOR ART

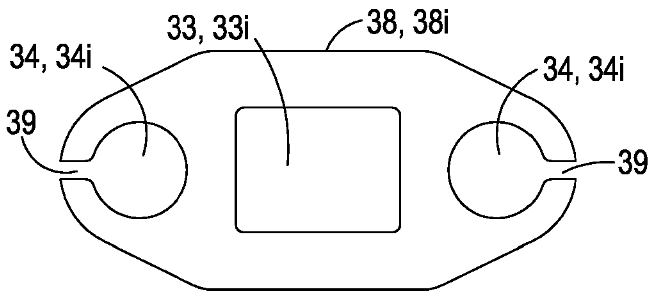

Fig.7

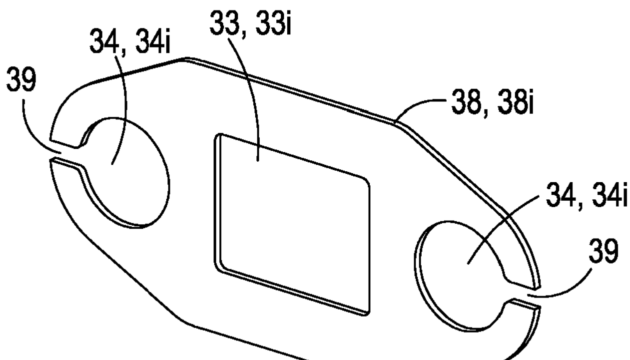

Fig.8

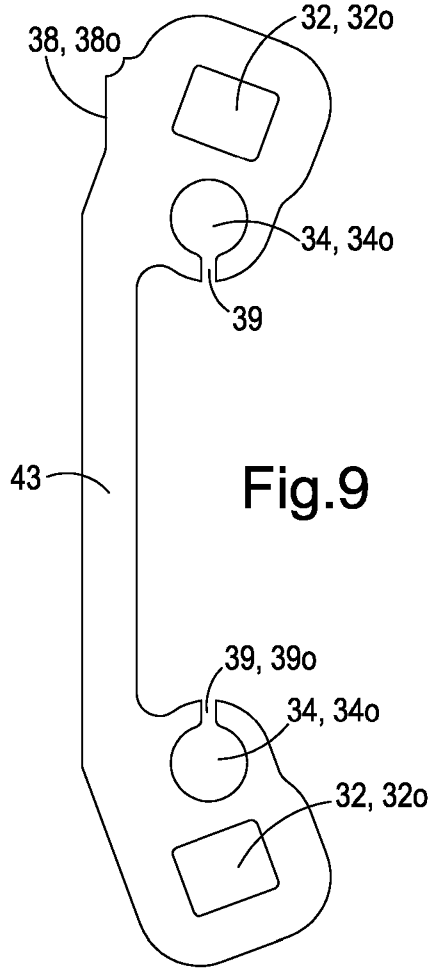

Fig.9

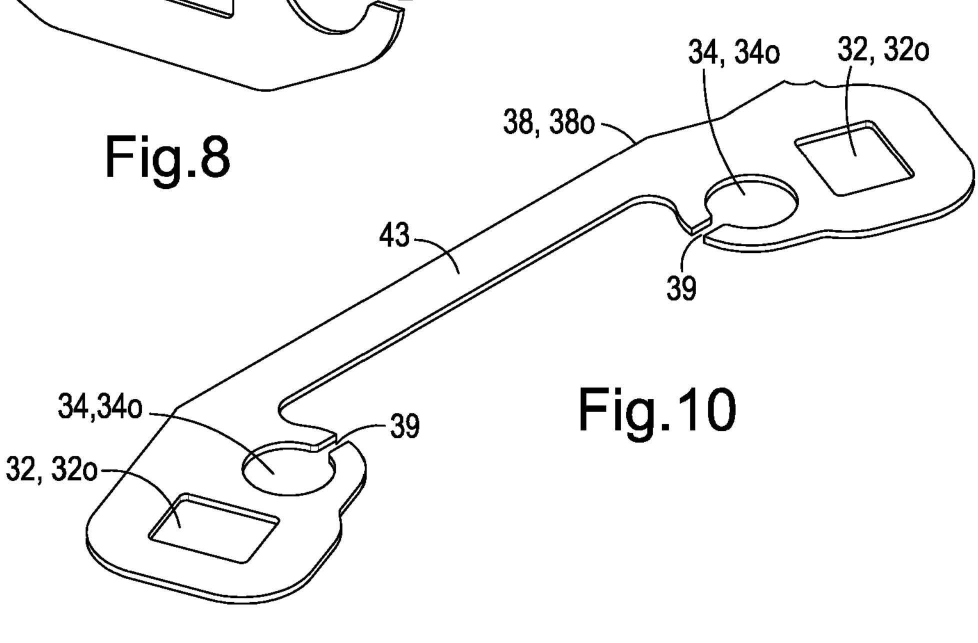

Fig.10

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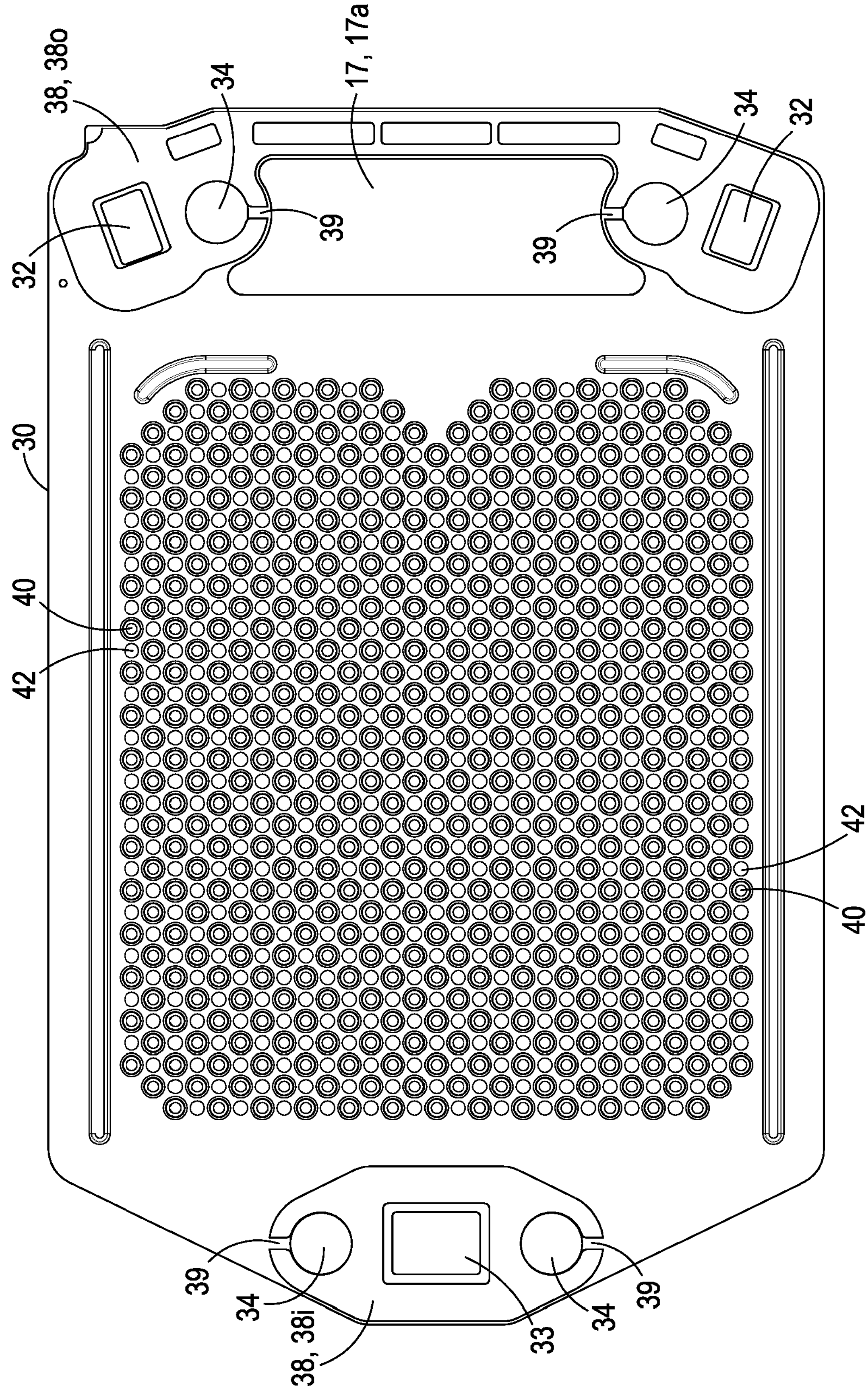

Fig.11

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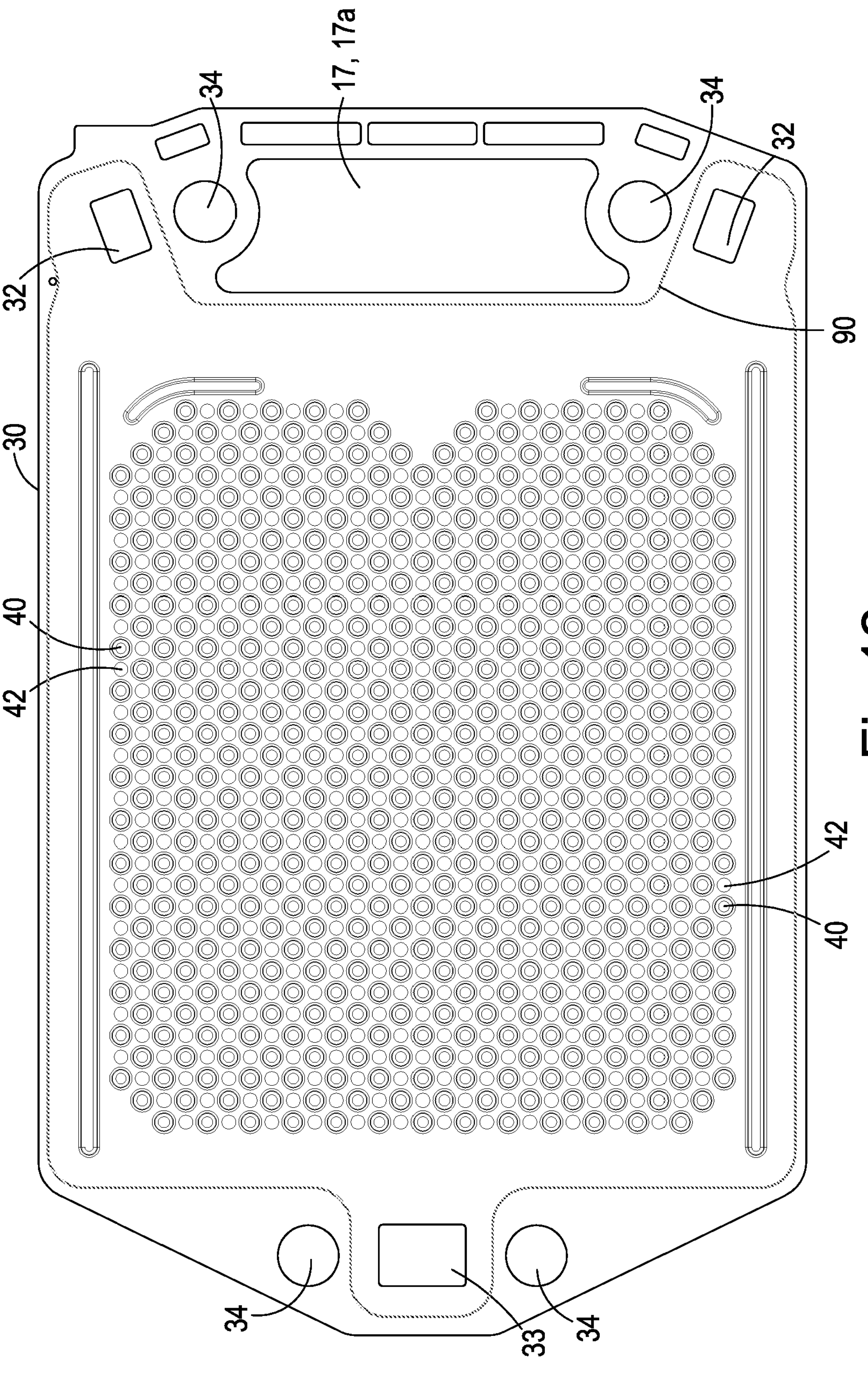

Fig.12

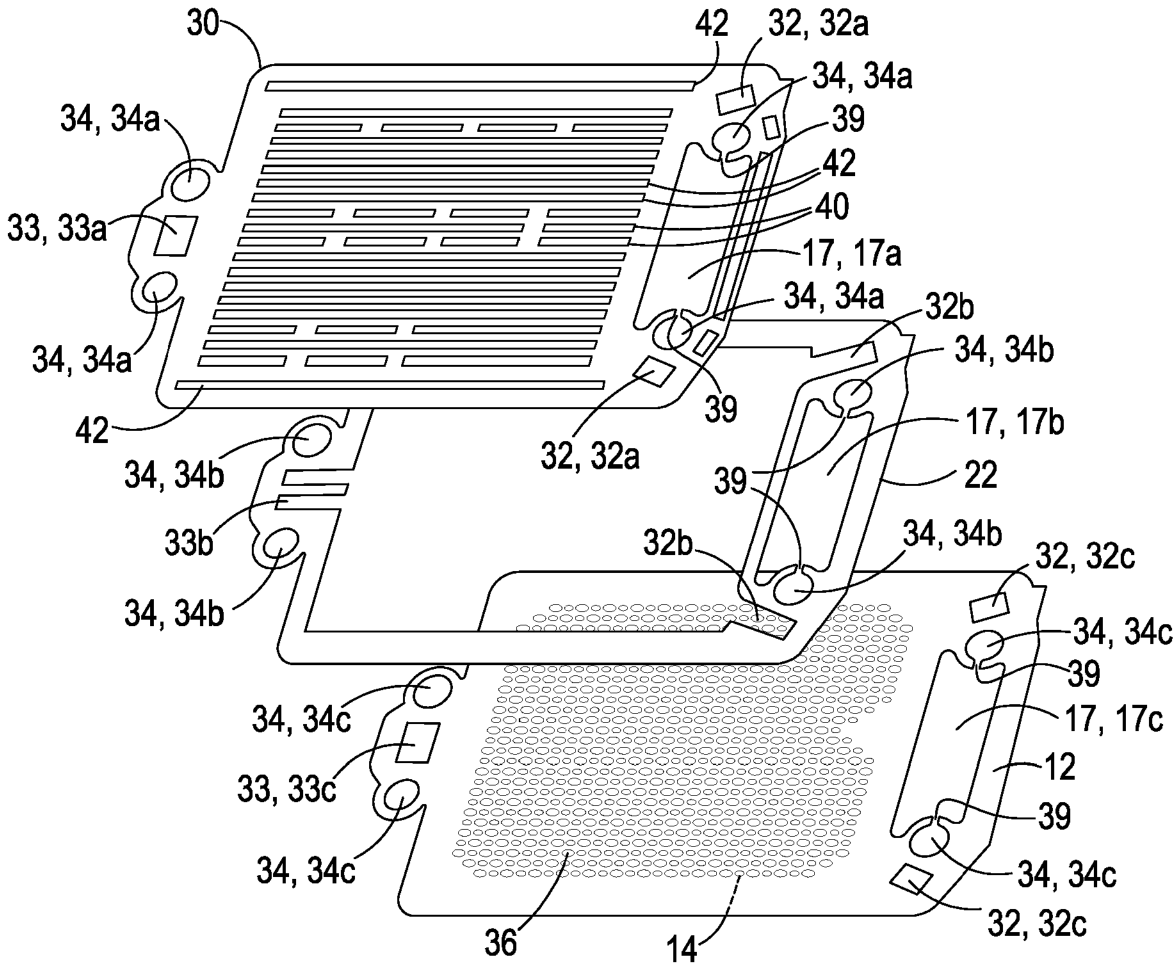

Fig.13

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A stack of intermediate temperature, metal-supported, solid oxide fuel cell units

The present invention relates to a stack of intermediate temperature, metal supported, solid oxide fuel cell units with improved life expectancy and durability.

An advanced fuel cell stack assembly 5 is known from WO2015/136295, the entire contents of which are incorporated herein by way of reference. It has, as shown in Figure 1 attached hereto, multiple active solid oxide fuel cell units (SOFCs) 10 arranged in a stack 1, with gaskets 38 fitted between each pair of neighbouring cell units 10. As shown and discussed in WO2015/136295, there can also be dummy cell units 8 within the assembly.

The assembly 5 is all held or compressed together by connecting nuts 3 and bolts 2 between end plates 4.

Each active cell unit 10 has multiple layers such as a metal (usually steel) support substrate 12, a spacer 22, and an interconnect 30, as shown in Figure 2. The steel substrate 12 contains therein a plurality of holes 36 extending therethrough, and overlying the holes there are the electrochemically active layers 14 – an anode, an electrode and between them an electrolyte. Preferred materials for these layers are discussed in the above PCT application. The spacer 22 then spaces that steel substrate 12 from the interconnect 30, typically with the electrochemically active layers 14 disposed on the outside of this fuel cell unit 10. These layers are then welded together to form the individual cell unit 10 with the interconnect 30 on one side of the steel substrate 12 and the electrochemically active layers 14 attached on the other side of the substrate 12 – see Fig 12 for a weld line 90 for a similar cell unit, albeit with a different peripheral shape. The weld line 90 would follow a corresponding path with the cell unit of figure 2. This arrangement thus provides an external electrochemically active layer (cathode outermost), with the weld line 90 sealing the fuel within the cell unit from air surrounding the cell unit – (the cell unit has internal fuel flow as the fuel is to contact the anode within the cell unit through underlying holes 36 in the metal substrate).

For forming a stack 1, many of these cell units 10 are stacked together - see, for example, Fig 3.

The interconnect 30 has surface relief, comprising various lumps or bumps or ridges 42, and corresponding indentations or grooves 40, imprinted or stamped therein, collectively defining two spaced generally planar (but with many gaps) surfaces, one of which (upper in Fig 2 and lower in Fig 3) is for having a cell unit – electrochemically active layers 14 facing down - placed thereon. The other surface of the interconnect 30 instead touches the steel support substrate 12 of its own cell unit 10 – through the spacer 22. Further, since the planar surfaces are not complete, they only touch in certain locations, whereby they won't block off many of the previously mentioned holes 36 formed in the steel support substrate 12 of its own cell unit 10, and will touch only a similarly restricted amount of the other cell unit's 10 electrochemically active layers' 14 outer surface.

The shape of the lumps, bumps, ridges, indentations and grooves, or such like, 40, 42 are also differently or oppositely arranged between neighbouring cell units to allow, for example, a bump 40 of a first cell unit 10 to align under an indentation 42 of a second cell unit 10, whereby any force from a first interconnect 30 of a first cell unit 10 against the electrochemically active layers 14 of a second cell unit 10 will be neutralised by a corresponding opposing force generated by the interconnect 30 of that second cell unit 10, etc., when the stack 1 is assembled and clamped together by the nuts 3 and bolts 2.

The lumps or bumps, ridges or troughs, etc. 40, and corresponding indentations or grooves 42, are also shaped and positioned to define passageways on either side of the interconnects 30, when stacked, for the air (usually on an outer surface) and fuel (usually on an inner surface), such as in Figure 3, so that the fuel cell stack can work when in operation.

In WO2015/136295, and preferably in the present invention, the fuel cell units are intermediate temperature, metal supported, solid oxide fuel cell units.

An example of a metal supported fuel cell stack 1, for giving a better illustration of this stacked effect, is shown schematically in Figure 3. The metal supported fuel cell stack

1 comprises multiple stacked fuel cell units 10, each of which has a flat steel plate - the metal support substrate 12, as in fig 2, with holes 36 drilled or laser cut through the substrate 12 for accessing a closest (usually anode) layer of the electrochemically active layers 14 that will be deposited on the steel substrate 12 from the other side of the substrate 12, a spacer 22 forming generally a ring around the opposite side of the steel substrate 12, and an interconnect 30 with dimples, troughs, ridges and bumps etc. 40, 42 for connecting with the next cell unit, all welded together generally around the electrochemically active layers 14 and any fuel inlet chimney, 33 and fuel outlet chimney 32, (see figures 2 and 12) to form the complete cell unit 10. As the holes 36 underlying the electrochemically active layers 14 extend no further than the expanse of the electrochemically active layers 14, the weld line 90 encloses the holes 36 to define an inner space with fuel channels 31 so that fuel will be able to flow inside the cell unit 10, in the inner space within the cell unit delimited by the weld line 90, through the fuel channels 31 between the dimples or troughs, without leaking (the holes 36 don’t leak due to the overlying electrochemically active layers 14 blocking them off), and the fuel will thus access the electrochemically active layers 14 through the holes 36.

In this arrangement, the air instead effectively surrounds the cell unit 10, flowing around the cell unit 10 and in between adjacent cell units 10 through air channels 23 and out through an air outlet 17, so that the air can contact the cathode of the electrochemically active layers 14 in the stack 1 (the cathode being the outer layer of the electrochemically active layers 14 of each active cell unit 10).

The weld line 90 is thus part of the arrangement that ensures that the fuel and air cannot mix within the cell unit 10.

These principals are all known from the prior art, such as the above mentioned PCT application, although the shape of the cell unit 10 in figures 11 and 12 is new.

Referring to Figures 1 and 2, in addition to the weld line 90 – similar to that of Figure 12, the fuel is separated from the air flowing around and through the fuel cell units by gaskets 38, the gaskets 38 having holes 32i, 33o in them – for the fuel ports 32, 33 (inlets 33i or outlets 32o) and bolt holes 34i, 34o. This prior art example has two forms of gasket - an inlet gasket 38i and an outlet gasket 38o. There are thus inlet gasket bolt holes 34i and outlet gasket bolt holes 34o. These bolt holes 34 allow the gaskets 38 to be retained within the stack 1 during stack assembly and compression by the bolts 2.

The bolt holes 34i,o of the inlet and outlet gaskets 38i,o, when the stack 1 is assembled (see figure 1, and note also figure 11), are aligned with bolt voids 34 for the bolts 2 in the cell units 10; and the fuel ports 33i, 32o of the inlet and outlet gaskets 38i,o, are aligned with the fuel inlet chimneys 33 and/or outlets chimneys 32 in the cell units 10. Fuel inlet chimneys 33 and/or outlets chimneys 32 in the cell units 10, and the aligned fuel ports of the gaskets 33i, 32o then complete substantially continuous internal fuel manifolding extending through/along the stack 1 with cell unit 10 access at fuel inlet ports 33b of the spacers 22 and fuel outlet ports 32b of the spacers 22. For the bolts 2, the respective alignment of the bolt holes of the interconnect, the spacer, the substrate, the inlet gasket and the outlet gasket 34 should be a straight void so that the bolts 2, which are commonly straight, can push through the stack 1. For the fuel manifolding, the path can be more tortuous, as fuel will travel around corners. Nevertheless, as shown it is usually also straight for convenience.

The fuel inlet and outlet chimneys 33, 32 provide cell unit 10 access via the fuel inlet and outlet ports 33b, 32b in the spacers 22, to provide entry and exit routes for fuel flow to or from each cell unit 10 to ensure activity from all cell units 10.

Once assembled, the bolts 2 will not touch the respective cell units 10 as that would earth the fuel cell units 10, thus rendering the stack 1 useless.

The bolts 2 are themselves earthed for safety.

See figure 1 for an example of this stacking/bolt arrangement.

The present inventors have noted, however, that in the product of the prior art, there have been a number of instances of failure at the gasket, with fuel mixing with air and leading to combustion, or more explosively, electrical shortage between the bolts and the metal of the cell units causing blowthrough through one or more gasket between the bolt void and the external air manifolding. The present invention is therefore intended to improve the design of the stack to extend the life expectancy of a fuel cell, and its gaskets, by preventing such failures.

According to the present invention there is provided a stack of intermediate temperature metal supported, solid oxide fuel cell units comprising multiple fuel cell units arranged in a stack wherein each fuel cell unit comprises a metal support substrate with electrochemically active layers, a spacer and an interconnect, wherein the metal support substrate, the spacer and the interconnect have bolt holes for compression bolts of the stack, at least one fuel inlet and at least one fuel outlet for fuel entry and exit into and out of the cell unit, and at least one air outlet for air venting, wherein bolt voids are formed within the stack by the alignment of the respective bolt holes for the compression bolts in the stack and a further void by the alignment of the respective air outlets for the air venting, characterised in that the bolt voids for the compression bolts are vented, either to the environment surrounding the stack or into an air outlet, to prevent build up of moisture, leaked or diffused hydrogen, or leaked ions, in the air in the bolt voids;

and by

- the venting being provided by slots provided in the bolt holes of any of the metal support substrate, the spacer and the interconnect;
- and/ or
- in the case where gaskets are located between neighbouring cell units in the stack, the gaskets having at least one fuel port aligning with fuel inlet or outlet chimneys in the cell units either side thereof, and at least one further bolt hole aligning with the bolt holes for the compression bolt in the stack either side thereof, the venting being provided by slots provided in the bolt holes of the gaskets.

Preferably, gaskets are located between neighbouring cell units. The gaskets may be integral to the cell units, but preferably the stack further has separate gaskets between neighbouring cell units in the stack, the separate gaskets having at least one fuel port aligning with fuel inlet or outlet chimneys in the cell units either side thereof, and at least one further bolt hole aligning with the bolt holes for the compression bolt in the stack either side thereof. The gaskets for an intermediate temperature metal supported fuel cell stack may be mica or talc based.

Preferably there are more than two bolt holes for compression bolts in each cell – ideally at least two at each end of the cell unit. Preferably the bolt voids formed therewith, in the stack, are all vented.

Preferably the gaskets each have two further bolt holes, thus bridging between the bolt holes in the neighbouring cell units.

Preferably the gaskets – preferably the separate ones – provide the venting by having their bolt holes slotted in a side thereof – preferably out to the outer edge of the gasket. The cell units themselves, however, could equally provide venting by their own bolt holes comprising a slot, although separate gaskets could tend to at least partially block such slots in the cell units, due to their greater compressibility, so having the slots in the separate gaskets is preferred.

There may be two or more fuel outlet ports for a cell unit, so the relevant gaskets therefor may have two or more fuel outlet ports - usually an appropriate number aligning over all the fuel outlet ports at an end or side of the fuel cell unit. It can likewise align over any or all bolt holes on that end or side.

The separate gaskets are typically arranged at two respective end regions of the individual cell units, i.e. at or near the narrow sides of a stack in the event of generally rectangular cell units.

The stack is preferably arranged with four bolts extending end to end of the stack, with two bolts at each narrow side – i.e. at two ends or end regions of the cell units. The gaskets thus preferably each have two bolt holes. Alternatively, more than one gasket may be fitted between each of the cell units at each end of each cell unit, but that complicates the assembly.

There can be slots for venting in each bolt hole of each separate gasket to give complete venting of the bolt voids, or alternatively there may be some vented gaskets and some non-vented gaskets, to reduce the extent of venting.

The cell units themselves, or some of them, may additionally or instead be vented, as mentioned before.

The present inventors developed this venting for the bolt voids as they realised that hydrogen, moisture or ions were somehow leaking into the bolts' voids and was building up enough to enable the failure. The mode of failure has thus been identified generally to be one or more of, or probably a combination of, combustion in the bolt voids due to diffused hydrogen in the bolt void reacting with the oxygen of the air therein, potentially explosively, due to the temperature of the stack – commonly between 500 and 700 degrees C for an intermediate temperature fuel cell assembly, ionisation from ions leaking from the gaskets, and electrical shorting due to the environment thereby produced. They concluded that the hydrogen was diffusing through the gaskets through the minuscule pores therein. Alternatively or additionally, it was concluded that ionisable elements in the gasket material were becoming liberated from the gasket, perhaps due to the combustion or general temperature of the fuel cell assembly and/or due to the compression forces exerted through the gaskets, and those ions were then accumulating in the bolt void over time, commonly less than a hundred hours of running, leading to a lowered electrical breakdown voltage and thus allowing an electrical short to occur between the bolt or tie bar and the cell units. The inventors thus looked to solve this and came up with the idea that venting could be provided to release the slowly diffusing hydrogen and ions into the larger airflow of the surrounding environment or the air outlet, thus removing the danger of an excessive hydrogen and ion build-up, whereby neither combustion of the hydrogen nor electrical short through the ions could occur, thereby removing that risk of failure. In brief, therefore, the bolt voids that initially were not thought of as being for any kind of air/fuel venting, are now being used as flow channels to vent any leaked ion gases out of such bolt voids, thus preventing the above-discussed modes of failure from occurring.

Preferably the gaskets have a shape, a part of which generally matches an adjacent part of the outside form of the cell unit so that in the stack the gaskets retain the generally neat and uniform form of the stack. The parts of the outside form of the cell units is typically the thinner or shorter sides of the cells.

These and other features of the present invention will now be described in further detail, purely by way of example, with reference to the accompanying drawings in which:

Figure 1 shows in exploded form a prior art stack arrangement as per the above mentioned PCT application;

Figure 2 shows in exploded form the arrangement of a cell unit within the stack;

Figure 3 shows in schematic form an arrangement of a stack showing the opposing form of the interconnects of the fuel cell units within the stack, and the gaskets between the fuel cell units;

Figure 4 shows a partial schematic section through the fuel cell units, fuel outlet chimney, bolt void and bolt of a form of fuel cell stack;

Figure 5 shows the H_2 (hydrogen) diffusion from an enclosed tie bar volume;

Figure 6 shows a separate inlet gasket from the fuel cell stack assembly of the above mentioned PCT application;

Figures 7 and 8 show an inlet gasket for the present invention for the fuel entry end of the cell unit;

Figure 9 and figure 10 show an outlet gasket for the present invention, but for locating at the fuel exit end of the cell unit;

Figure 11 shows the gaskets positioned on an interconnect of a cell unit - a further cell unit then sits thereon with its electrochemically active layers sitting on the interconnect of the shown cell unit; and

Figure 12 shows the cell unit of figure 11, but with the gaskets removed and the weld line illustrated.

Referring first of all to Figures 1, 2 and 3, these have already been described above and thus no further discussion will be provided in this section. This general arrangement is an arrangement of fuel cell assembly 5 that can benefit from making use of the present invention.

Referring next to figure 4, there can be seen a schematic arrangement for a fuel cell stack assembly 5 that can also use the invention – without dummy cell units 8. It shows multiple cell units 10 in a stack 1, capped with an earthed top end plate 4 with an electrical insulation gasket 6, usually made of mica, between the top end plate 4 and the stack 1. A bolt 2 (usually four, as in fig 1) and nut 3 (again usually four – to correspond with the bolts 2) then compresses the whole lot together, with gaskets 38 between the fuel cell units 10, and between the top fuel cell unit 10 and the electrical insulation gasket 6. In this arrangement air can flow through an air channel 23 above each fuel cell unit 10 (figs 3 and 4) and out through its air outlet 17 (a larger air chimney through the stack 1 as shown more clearly in figs 1 and 2, and 11 and 12). Fuel instead flows through a fuel channel 31 defined by the spacer and dimples/troughs above, and thus inside each fuel cell unit 10 from the fuel inlet chimney 33, through the fuel inlet port 33b of the spacer 22 to the fuel outlet ports 32b of the spacer 22 and then out through the stack's fuel outlet chimney 32.

As can be seen in Figure 4, the bolt 2 extends through the bolt void 34 without touching the sides of the void – i.e. without touching the cell units 10. This prevents the bolt 2 from earthing the fuel cell stack 1. A gap 35 is shown in Figure 4. It is an area into which hydrogen and ions were tending to leak in the prior art non-vented bolt voids.

Referring next to figure 6, an example of the inlet gaskets 38i of the prior art is shown. As can be seen, the gasket 38i has two bolt holes 34i located either side of a fuel port 33i. Referring to figure 1, this gasket 38i can be seen approximately at the bottom of the middle cell unit of the drawing. It is arranged such that the two bolts 2 thread through the bolt holes 34i of inlet gasket with the fuel port 33i of inlet gasket, –together with the fuel inlet ports 33i, 33a,b,c of the various cell units and the other gaskets, thus also producing a fuel inlet chimney 33 or fuel manifold along the stack. As there is no venting in these gaskets 38, or in the fuel cell units 10, in the fuel cell assembly of Figure 1, the above-mentioned hydrogen and ion build-up can occur.

Referring next to figure 7 and 8, a similar inlet gasket 38i is shown, albeit with a different external shape, which inlet gasket 38i still has the two bolt holes 34i and the fuel port 33i in the middle, but this time the two bolt holes 34i of inlet gasket are slotted to the surrounding environment by two slots 39 – one for each bolt hole 34i. Thus, when these inlet gaskets 38i are stacked with the respective fuel cell units 10, the bolt void 34 formed by the bolt holes 34i of the inlet gaskets 38i and the fuel cell units 10 is now vented to allow diffusion of any hydrogen build-up out of the bolt void 34 and into the surrounding environment. For this stack 1, the surrounding environment is air surrounding the stack.

This inlet gasket 38i has a length of about 45mm and a width of about 21mm. It is between 0.5 and 0.9mm thick. Other thicknesses can be used where needed to accommodate higher or lower bumps or ridges 40 in the interconnect 30. Likewise, widths and lengths can be adjusted depending upon the size or shape of the cell units and the location of the bolt holes 34 and fuel inlet ports 33.

The bolt holes 34 preferably have a diameter of about 8.5mm for receiving an M8 bolt – or a bolt 2 having approximately an 8mm diameter. The gap 35 is thus around 0.25mm on each side of the bolt. The gap 35 can thus be kept small. Larger or smaller gaps might also be provided. Furthermore, larger or smaller holes might be used for larger or smaller bolts 2.

The fuel inlet port 33 is preferably generally rectangular, as shown –preferably around 14mm by 11mm, or having a cross sectional area of around 160mm2. This provides enough area for the fuel transmission into the fuel cell unit. Smaller or larger fuel inlet ports 33 may be provided instead, and would be preferred for stacks requiring lower or higher fuel delivery volumes.

The slots 39 are around 1.6mm wide. For the given space around the bolt 2, this has been found adequate for dispersal of hydrogen and ions. The slot 39 can be wider or narrower for increasing or slowing dispersal rates, or if more or less hydrogen and ions need dispersal.

Generally useful sizes of inlet gaskets 38i for the fuel input end of the fuel cell unit 10 will have no greater than twice these dimensions, and no less than half these dimensions, although they are sized to fit the size of the cell unit, and as such can be of any appropriate size given the fuel cells.

Referring next to figures 9 and 10, the outlet gasket 38o for the fuel exit end of the stack 1 is instead shown. This outlet gasket 38o also has two bolt holes 34o, but this time positioned inward of two fuel ports 32o. Furthermore, the outlet gasket 38o has a more elongated form with an arm 43 connecting two ends (the arm 43 being thinner in plan than the ends), the arm 43 bridging, in use, behind the air outlet 17 of the two fuel cell units 10 against which it will be fitted, one of which is shown in figure 11.

Figure 11 also shows the outlet gasket 38o overlying the other end of the fuel cell unit 10. Like the inlet gasket 38i of the invention, this outlet gasket 38o has slots 39 for venting the bolt holes 34o of outlet gasket, but this time for venting into the air outlet 17.

Although the gaskets 38i,o in Figures 6 to 10 are shown to have the slots 39 for venting their bolt holes 34i,o, as previously discussed it is possible instead or in addition for the fuel cell units 10 to have vents for their bolt holes 34a,b,c. See Figure 13 for such an embodiment. In that embodiment, the metal support substrate 12, the spacer 22 and the interconnect 30 all comprise slots 39 in the respective bolt voids 34 at the fuel outlet end of the cell, in the same manner as the outlet gaskets 38o are provided with slots 39 in the previous embodiment, thus providing venting from the bolt voids 34 to the atmosphere. It is to be appreciated, however, that it is interchangeable as to where the slots might be provided – they need not be in each component, nor in just one set of the components, but they may be in any selection of components in a given stack, at either or both ends (fuel inlet end and/or fuel outlet end). For example, in one embodiment the spacer 22 comprises the slots 39 for venting the bolt voids 34 whereas the bolt holes 34a of the interconnect and the bolt holes 34c of the substrate comprise a full perimeter wall, i.e. no slots.

Returning to the first embodiment, the outlet gaskets 38o of this embodiment have a length of about 110mm and a width of about 27mm. It is between 0.5 and 0.9mm thick. Other thicknesses can be used, e.g. where needed to accommodate higher or lower bumps or ridges 40 in the interconnect 30. Likewise, widths and lengths can be adjusted, e.g. depending upon the location of the bolt holes 34o of the outlet gaskets and the fuel ports 32o of the outlet gaskets.

The bolt holes 34o of the outlet gasket preferably have a diameter of about 8.5mm for receiving an M8 bolt – or a bolt 2 having approximately an 8mm diameter. The gap 35 between the bolt holes and the bolt is thus again about 0.25mm (on either side of the bolt). Larger or smaller gaps 35, or larger or smaller holes of outlet gasket 34o, might be used, e.g. for larger or smaller bolts 2.

The fuel ports 32o of the outlet gaskets are each preferably around 10mm by 8mm, or have a cross sectional area of around 80mm2. As there are two, they can be half the size of the single fuel ports 32i of the inlet gaskets. This provides enough area for the fuel transmission out of the fuel cell unit 10. Smaller or larger fuel ports 32o of the outlet gaskets may be preferred, e.g. for lower or higher fuel delivery volumes.

The slots 39 are around 1.6mm wide. For the given space around the bolt 2, this has been found adequate for dispersal of hydrogen and ions. The slot 39 can be wider or narrower for increasing or slowing dispersal rates, or if more or less hydrogen and ions need dispersal.

Generally useful sizes for the outlet gasket 38o for the fuel output end of the fuel cell unit 10 will have no greater than twice these dimensions, and no less than half these dimensions, although they are sized to fit the size of the cell unit, as with the gaskets at the inlet end.

Referring finally to figure 5, the speed of hydrogen diffusion out of each bolt void's 34 volume, once the slots 39 are provided in the gaskets 38, is approximately shown. As can be seen, within half a second of entry into the bolt void's 34 volume, substantially all hydrogen has already diffused out of the bolt void's 34 volume. As a consequence, it is clear that the slots, or venting, minimise the risk of hydrogen build-up and thus the environment within the bolt void 34 is no longer susceptible to combustion or arcing (shorting) between the bolts 2 and the fuel cell units 10 (i.e. across the gap 35 therebetween).

Ideally the gap 35 is maintained during assembly of a stack at a distance of no less than 0.1mm throughout the length of the stack 1.

The present invention has hereby been disclosed purely by way of example. Modifications in detail may be made to the invention within the scope of the claims appended hereto.

Reference signs are incorporated in the description solely to ease its understanding, and are not limiting the scope of the claims. The present invention is not limited to the above embodiments only, and other embodiments will be readily apparent to one of ordinary skill in the art without departing from the scope of the appended claims.

Reference signs:

1 – Stack
2 – Bolt
3 – Nut
4 – End plate
5 – Fuel cell stack assembly
6 – Insulation gasket
8 – Dummy cell unit
10 – Cell unit
12 – Metal support substrate
14 – Electrochemically active layers
17 – Air outlet
17a – Air outlet of interconnect
17b – Air outlet of spacer
17c – Air outlet of substrate
22 – Spacer
23 – Air channel
30 – Interconnect
31 – Fuel channel
32 – Fuel outlet chimney
32a – Fuel outlet port of interconnect
32b – Fuel outlet port of spacer
32c – Fuel outlet port of substrate
32o – Fuel port of outlet gasket
33 – Fuel inlet chimney
33a – Fuel inlet port of interconnect
33b – Fuel inlet port of spacer
33c – Fuel inlet port of substrate
33i – Fuel port of inlets gasket
34 – Bolt void
34a – Bolt hole of interconnect
34b – Bolt hole of spacer

34c – Bolt hole of substrate

34i – Bolt hole of inlet gasket

34o – Bolt hole of outlet gasket

35 – Gap

36 – Holes (Substrate)

38 – Gaskets

38i – Inlet Gasket

38o – Outlet Gasket

39 – Slot

40 – Lumps or bumps, ridges or troughs

42 – Indentations or grooves

43 – Arm

90 – Weld line

Claims

1. A stack of intermediate temperature metal supported, solid oxide fuel cell units arranged in a stack

wherein each fuel cell unit comprises a metal support substrate with electrochemically active layers, a spacer and an interconnect,

wherein the metal support substrate, the spacer and the interconnect have bolt holes for compression bolts of the stack, at least one fuel inlet port and at least one fuel outlet port for fuel entry and exit into and out of the cell unit, and at least one air outlet,

wherein bolt voids are formed within the stack by the alignment of the respective bolt holes for the compression bolts in the stack and a further void by the alignment of the respective air outlets,

characterised in that the voids for the compression bolts are vented, either to the environment surrounding the stack or into an air outlet, to prevent build up of moisture, leaked or diffused hydrogen, or leaked ions, in the air in the bolt voids;

and by

- the venting being provided by slots provided in the bolt holes of any of the metal support substrate, the spacer and the interconnect;
- and/ or
- in the case where gaskets are located between neighbouring cell units in the stack, the gaskets having at least one fuel port aligning with fuel inlet or outlet chimneys in the cell units either side thereof, and at least one further bolt hole aligning with the bolt holes for the compression bolt in the stack either side thereof, the venting being provided by slots provided in the bolt holes of the gaskets.

2. The stack of claim 1, further comprising gaskets between neighbouring fuel cell units in the stack, the gaskets having:

a) at least one fuel port aligning with either a fuel outlet chimney or a fuel inlet chimney in the cell units located either side thereof, and

b) at least one bolt hole aligning with bolt holes for the compression bolt in the cell units either side thereof.

3. The stack of claim 2, wherein the gaskets are mica or talc based.

4. The stack of any preceding claim wherein there are at least two bolt holes for compression bolts at each end of the cell units.

5. The stack of claim 4, when dependent upon claim 2, wherein the gaskets vent all the bolt voids for the compression bolts.

6. The stack of claim 5, wherein the gaskets each have two bolt holes.

7. The stack of any preceding claim, when dependent upon claim 5, wherein the gaskets provide the venting by their bolt holes comprising a slot in a side thereof out to an outer edge of the gasket.

8. The stack of any preceding claim, when dependent upon claim 2, having two or more fuel outlet ports for each cell unit, wherein the relevant gaskets therefor also have two or more fuel outlet ports.

9. The stack of any preceding claim, wherein at least some of the cell units have vents for their bolt holes.

10. The stack of any preceding claim, wherein at least some of the bolt voids are vented to the environment surrounding the stack.

11. The stack of any preceding claim, wherein at least some of the bolt voids are vented into an air outlet 17 of the stack.